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THE AMYLOPLAST AS A GRAVITY SENSING DEVICE IN PLANTS

Abstract

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A. Carl Leopold
David A. Priestley
Boyce Thompson Institute
Ithaca, NY 14853

Gravity sensing tissues of plants are almost invariably associated with starch-bearing plastids, the amyloplasts. A precise role of amyloplasts in gravity sensing is widely accepted, on the basis that their high density (1.5) makes them the most rapidly moving cell component upon gravity stimulation, and the observation that variations in size alter their gravity sensing in a manner predicted by Stokes Law (Hertel et al., 1969). While there is agreement that the amyloplast is the most usual gravity sensing component (Wilkins, 1977; Juniper, 1976), there is no understanding of how the movement of these organelles might bring about a physiological gradient across a cell or tissue. A major objective of this study has been to examine the amyloplast itself and to attempt to define means by which movement of the organelle could bring about a physiological gradient.

As a first step in this study, we have prepared intact amyloplasts from several geosensitive tissues. The extreme fragility of amyloplasts may well be a consequence of their enclosure of large, heavy starch grains in a fragile membrane envelope; but attempts to isolate them from aqueous preparations end up with a large proportion of broken amyloplasts. As an alternative we have utilized a non-aqueous method adapted from the work of Liu (1979). Coleoptiles or root tips of corn are frozen in Freon-12, lyophilized and ground in cold hexane. A fracture plane falls preferentially around the organelle and the fragments sieved (15 μm) and fractionated in hexane give a good yield of amyloplasts. Electron and light microscopy confirm the presence of intact amyloplasts. The extent of contamination of the preparation with other cell components was defined by marker enzymes (pyruvate kinase for cytosol and glutamate dehydrogenase for mitochondria).

A second approach to defining the nature of amyloplast action has involved measurement of the surface charge on the organelle. Intact amyloplasts are released from fresh tissue by chopping and sieving through a 10 μm sieve, and the organelles are electrophoresed using a microscopic electrocataphoresis cell. We have found that there is a negative surface charge on the amyloplast, and work in progress will characterize the zeta potential and hence permit the estimation of the nature and magnitude of the surface charge. In contrast to the negative charge on the amyloplast, the starch grains themselves have a distinct positive charge.

A third approach is to investigate the extent of microfilament (actin) networks in geosensitive cells on the possibility that the movement of the amyloplasts through the cytoplasm may serve to bring them in contact with

such an endoskeletal feature of the cytoplasm. Inconsistencies in the kinetics of geosensing and the current concept of statoliths resting on the plasmalemma of the cell (Johnsson and Pickard, 1979) might be resolved if reports of the presence of microfilaments in plant cells (Farere and Jackson, 1975) prove to be correct. We are attempting to observe such filaments in geosensitive tissues using a fluorescently labeled fungal toxin (phallicidin) which binds to microfilaments with high specificity (Barak et al., 1980).